AATT DAG-TM Research Goals … CE-11

"Appropriately equipped aircraft are given clearance to merge with another arrival stream, and/or maintain in-trail separation relative to a leading aircraft."

Phase 1: Self-space on an FMS arrival.

Phase 2: Self-merge with aircraft on another arrival stream.

Phase 3: Self-merge & space while free maneuvering in an arrival corridor.

Note: "free maneuvering" is limited to making small (tens of seconds) adjustments in spacing or arrival time.

Most changes are in green font.

CE-11 Tiger Team

- Bryan Barmore, Co lead
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CE-11 Goals and Objectives

- Increase throughput
- Maintain/increase safety
- Operationally acceptable
- Reduce controller workload
- Increase efficiency … a bonus

Quantitative goal: 20% increase in throughput for all of AATT.

DAG CE-11 Scenario Events: TRACON RTAs, Merging and Spacing

Aircraft arrive at TRACON feeder fixes within ~15 seconds of scheduled time.

The scheduled time is based on the estimated time to fly to the merge point on an FMS trajectory.

Controllers + ground DST determine runway, sequence and STA at the final approach fix or runway.

Controllers clear pilots of equipped aircraft on FMS transition, a required time of arrival and a spacing interval behind an aircraft.

For equipped aircraft, pilots have the FMS compute a speed profile to meet the RTA.

For unequipped aircraft, controllers use advisory tools to assign a lateral path and speed.

Pilot engages LNAV, VNAV and assigned spacing to fly the profile. If the winds are reasonably close to those predicted, the aircraft should meet the assigned RTA.

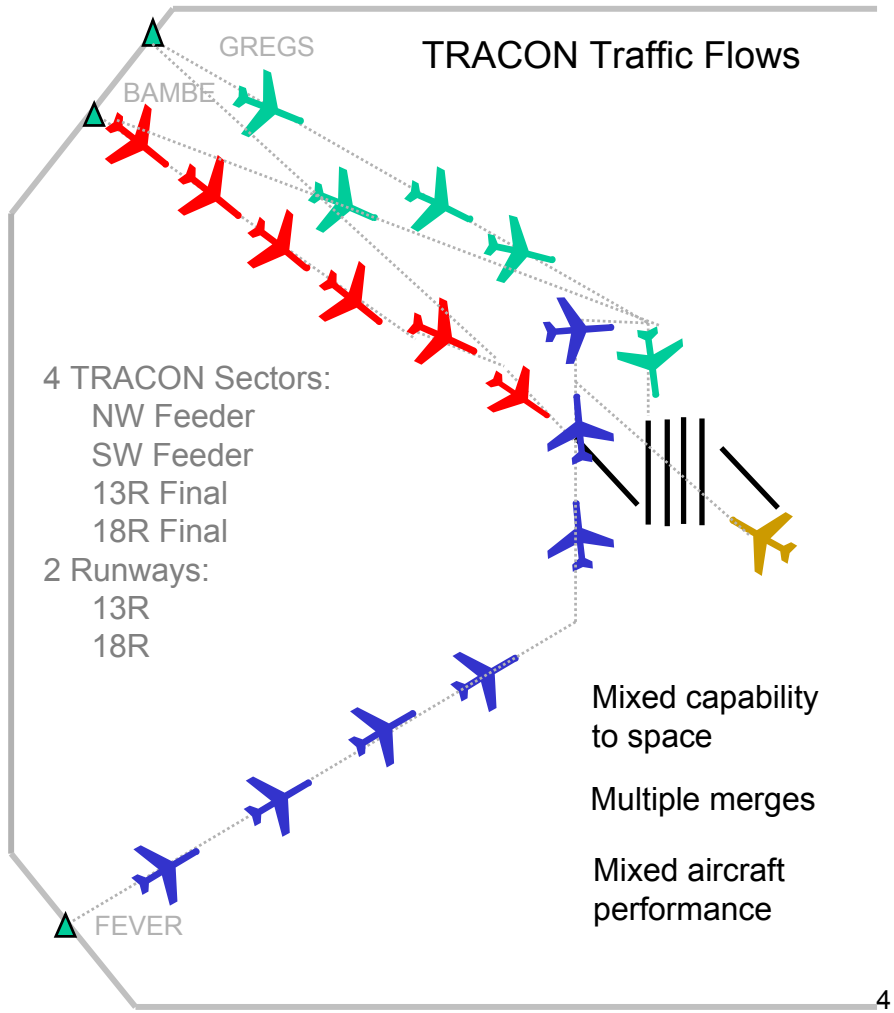
Nominally the aircraft follows the VNAV speed profile.
Capable aircraft can be cleared to self space.

Controllers use advisory tools to support conformance monitoring.

Merge and space clearances terminate at a pre specified altitude above the runway.

Automatic information exchange:
- Broadcast aircraft ADS state.
- Broadcast descent winds to synchronize trajectory computations.
- Downlink final approach speed
- Broadcast FMS trajectory whenever it changes

RTAs or speed advisories to meet STAs to get aircraft close then relative spacing to fine tune.



CE-11 Assumptions

- Aircraft arrive at meter fixes within 15 seconds of schedule with runway assigned (assume schedule is computed by TMA.)
- STAs at the merge point can be used by the controller to coordinate the flows from multiple corner posts
- The sequence at the merge point is based on the sequence in each stream and a FCFS priority at the merge point. I.e. no passing within a stream.
- FMS routes exist from the meter fix to the final approach fix
- Ground and air trajectory computations are compatible
- Aircraft broadcast by ADS-B airspeed and heading approximately every thirty seconds. The ATSP and other aircraft can use this information to accurately estimate the wind along the FMS route.
- Mix of aircraft capability to self-space or not
- Mix of turboprops, small, large, B757 and heavy aircraft.
- No severe convective weather in the TRACON
- Controller is responsible for separation

CE-11 Issues and Assumed Answers

- When are landing runways assigned? … Assume prior to reaching the TRACON.
- When are meter fixes assigned? … Assume prior to TOD.
- How much do aircraft have to modify their merge point ETA in the TRACON? … Assume about 20 seconds maximum.
- How are RTAs communicated? … If used, assume by datalink.
- Can aircraft downlink ETAs at the merge waypoint? … Assume yes but ....
- Can equipped aircraft update their lateral path within charted constraints to meet the RTA? … Assume not but ....
- Do we allow front loading? … Assume not but ....
- Spacing on time history or distance? … Assume time history.
- When are spacing clearance objectives required to be met? … Assume at the merge point.
- Multiple RTAs? … Assume one RTA at a time but ....
- CD&R required in the TRACON? … Assume not.
- Phraseology … Assume other aircraft call sign can be used in clearance.
- Switching from RTA to spacing … assume switch done by controller

CE-11 Roles and Responsibilities

TRACON RTA and spacing clearance

- Controller responsible for separation
- Flight crew can be cleared to maintain in-trail spacing, +/- buffer
- Controller can cancel clearance at any time … redundant

CE-11 Ground-side Capability

- Calculate a sequence and schedule for DFW runways 13R and 18R
- Provide speed and spacing advisories
- Provide trial plan capability similar to en route tool … optional
- Provide support for detecting nonconforming aircraft
- Displays will include a timeline with fast / slow time of arrival envelope
- Displays will be capable of showing time history spacing circles
- Displays will be able to show an estimate of when spacing clearance will be met
- Display will show if aircraft are equipped for spacing and if cleared for spacing
- Controller will be able to change spacing interval

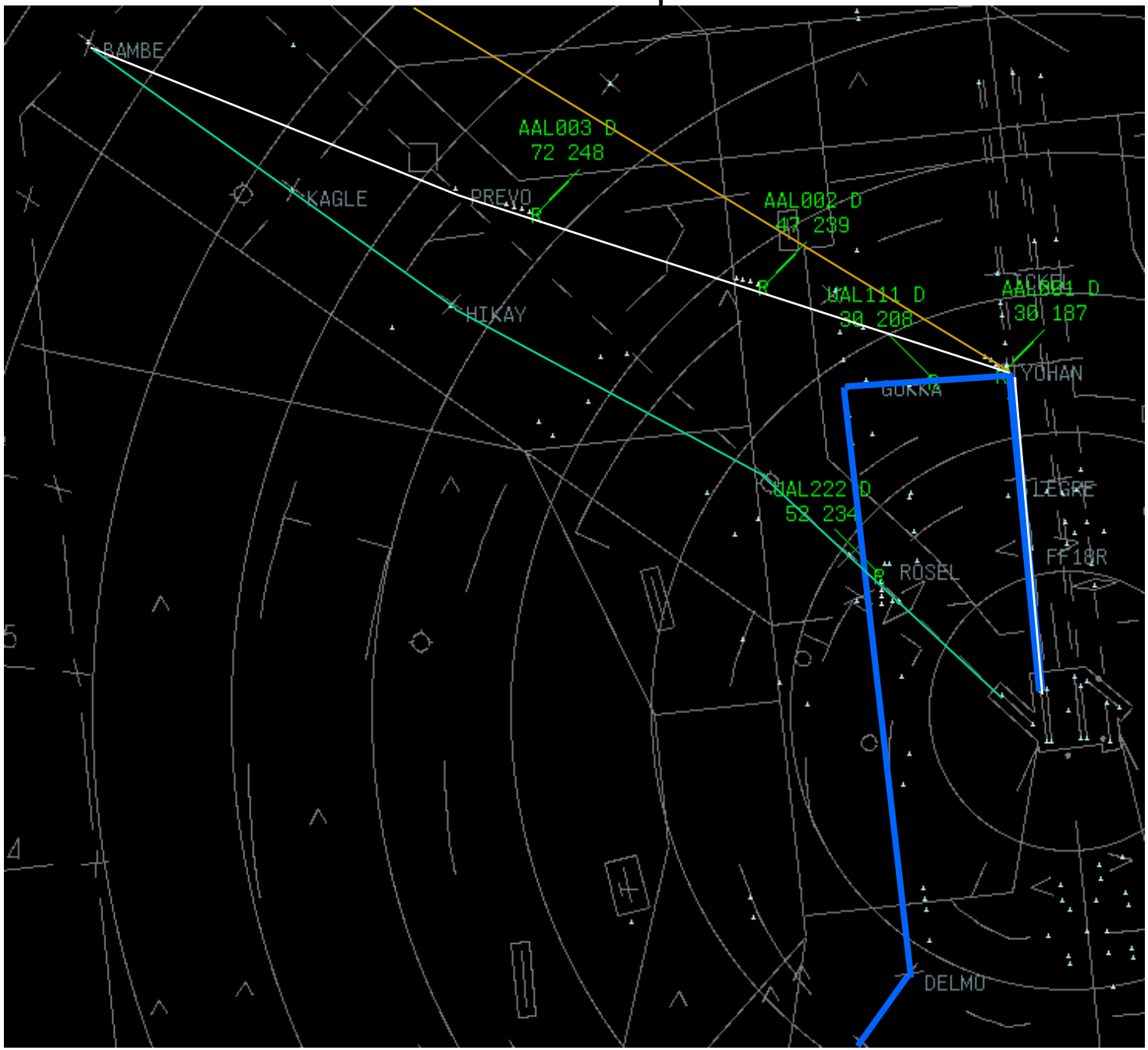
CE-11 Air-side Capability

- **Unequipped aircraft**
  - Circa 2003 FMS capabilities
  - Broadcast their state
  - Broadcast airspeed and heading for wind estimation
  - Broadcast their FMS trajectory when it changes … nice but not necessary
- **Equipped aircraft**
  - Can meet an assigned RTA by modifying their nominal speed profile
  - Have guidance and displays to merge then space behind a designated aircraft
  - Optionally can make minor modifications to their lateral path to meet an RTA

CE-11 Datalink

- ADS-B … automatic
  - Broadcast aircraft ADS state
  - Broadcast airspeed and heading for wind estimation
  - Uplinked descent winds to synchronize trajectory computations … assume done in en route airspace
  - Broadcast FMS trajectory whenever it changes … nice but not necessary
- CPDLC … all optional
  - Runway
  - Lateral route
  - Speed
  - RTA
  - Lead aircraft and spacing interval

DAG-TM CE-11 TRACON Air Space & FMS Transitions



En Route / TRACON "Letter of Agreement"

- Acceptance of autonomous aircraft in CE-5
  - The low altitude en route controllers are responsible for delivering a good flow of aircraft to the TRACON.
  - Autonomous aircraft are implicitly accepted into the TRACON. (No special communication is required for a free flight aircraft to enter the TRACON.)
- Handoff to the TRACON
  - Arrivals for DFW 13R or 18R are handed off to Regional Approach at 118.1
  - Arrivals for DAL 13L are handed off to Regional Approach 119.87
- When aircraft can be worked by the TRACON.
  - The TRACON may start working aircraft when they are within approximately 10 nm of the TRACON boundary.

Update

Experimental Conditions

- Traffic scenarios to test/stress the system
- Non conforming aircraft
- ----------
- Flow upsetting event … for example, change spacing matrix
- ...

Challenges

- En route / TRACON traffic flow … “impedance match”
- How to cope with nonconforming aircraft.
- How to build a gap for a missed approach.
- How to cope with a change in the wake vorix spacing matrix or other flow upsetting event.
- Load balancing - occasional aircraft from another meter fix ... pFAST.
- Front loading
- Dependant runway operations

Self-spacing speed guidance

- The self-spacing guidance commands about a 5 knot change in speed for each 1 second of spacing error.
- The change in commanded speed is limited to ~30 knots from the nominal speed profile.
- Self-spacing command speed is relative to the speed of the lead aircraft when it was at ownships current distance from the runway
- Maximum commanded speed is limited to 250 knots below 10,800 ft.
- Minimum commanded speed is limited to 150 knots.
- The self-spacing guidance will reduce spacing errors by approximately 20 seconds between BAMBE and POPPA.

Things to do:

- Check on TMA & pFAST capabilities for scheduling
- Check on the compatibility of CE-11 with TMA & pFAST
- Determine nominal flying times from meter fixes to runways
- Calculate through put with various aircraft mixes and arrival time accuracy
- Revisit delay balancing (front loading) analysis
- Perform throughput analysis … monte carlo study
- Software
  - Trajectory computations
  - Guidance to “intercept localizer”
  - Provisional trajectories for ETA and STA calculations
  - Speed advisories to meet STAs
  - Lateral trial plan
  - CPDLC

DELMO and YOHAN FMS Transitions to 18R

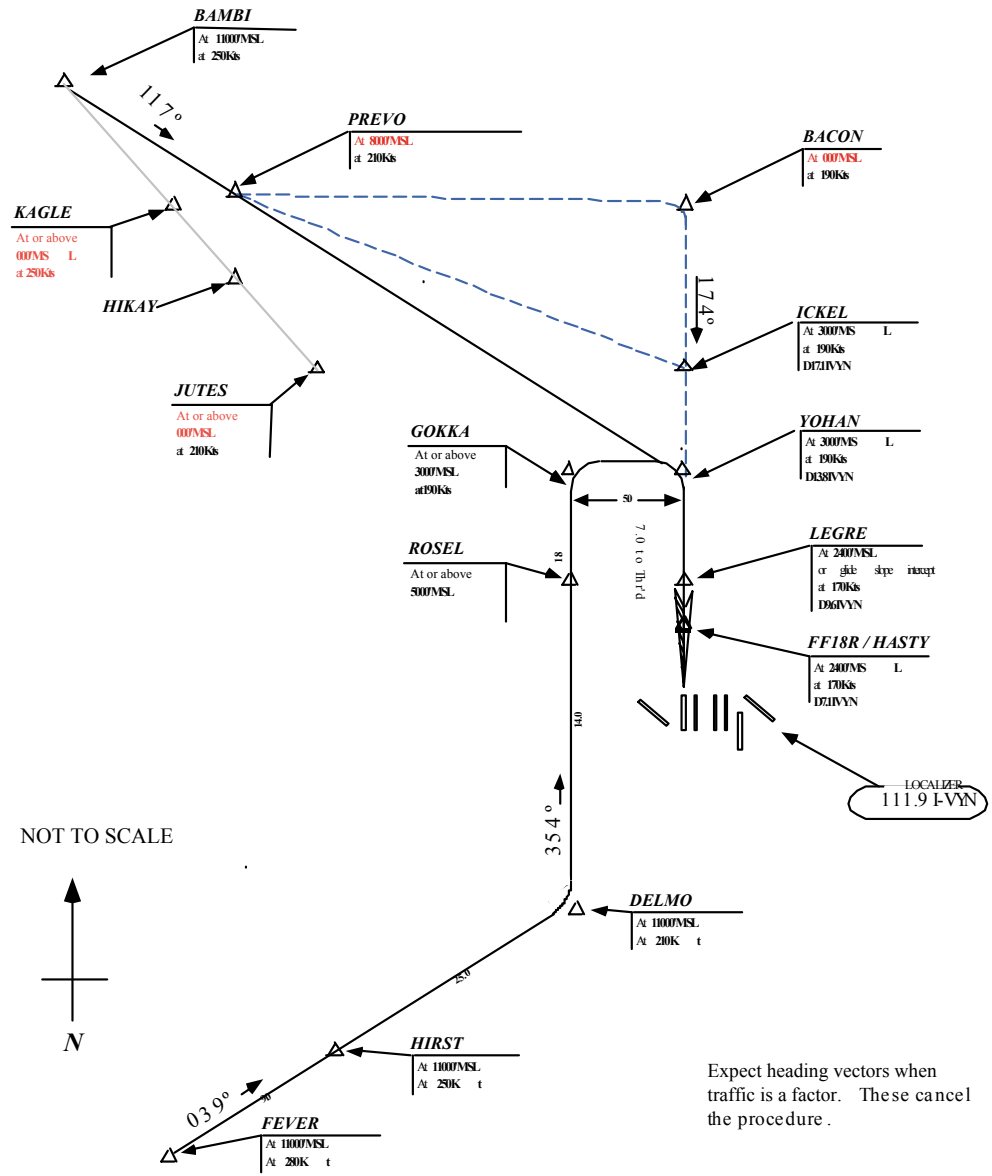
NASA 24 JAN 03

ATIS 123.775

DELMO & YOHAN FMS TRANSITIONS TO 18R
DALLAS-FT WORTH, TEXA S
DALLAS-FT WORTH, INTL

DELMO & YOHAN FMS TRANSITIONS TO 18R

(FOR USE BY SLANT E (/E) OR SLANT F (/F) AIRCRAFT ONLY)



Expect heading vectors when traffic is a factor. These cancel the procedure .

KDFW ILS Rwy 13R & 18R Approach Charts

FOR SIMULATION USE ONLY

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KDFW
DALLAS-FT WORTH INTL
JEPPESEN DALLAS-FT WORTH, TEXAS
4 FEB 00 (61-1)
ILS Rwy 13R

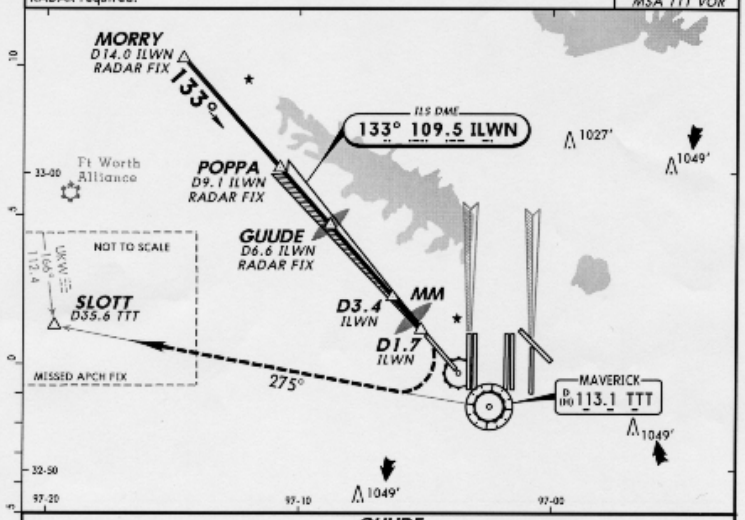
D-ATIS Arrival	REGIONAL Approach (R)	DFW Tower West	DFW Tower East	Ground West	Ground East
123.77	133.15 118.1	124.15 134.9	126.55 127.5	121.85	121.65 121.8

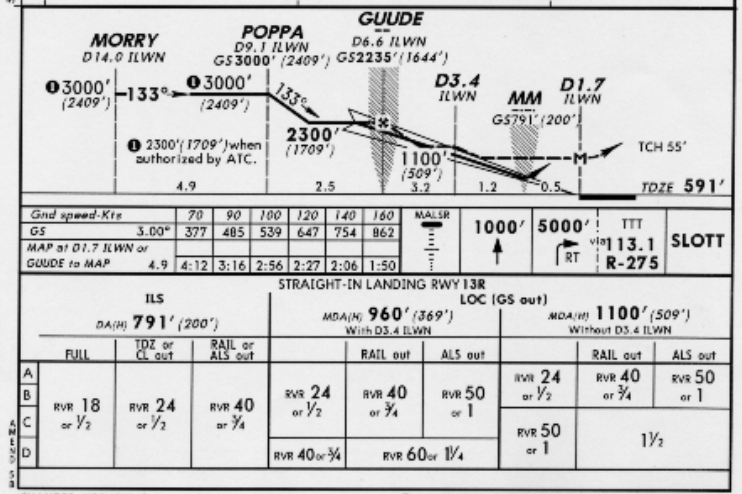
LOC ILWN	Final Apch Crs	GS GUUDE	ILS DA(H)	Apt Elev 603'
109.5	133°	2235' (1644')	791' (200')	TDZE 591'

MISSED APCH: Climb to 1000' then climbing RIGHT turn to 5000' outbound via TTT VOR R-275 to SLOTT INT/D35.6 TTT.

RADAR required.

2600' 3500' MSA TTT VOR





Gnd speed-Kts	70	90	100	120	140	160
GS 3.00°	377	485	539	647	754	862
MAP at D1.7 ILWN or GUUDE to MAP 4.9	4:12	3:16	2:56	2:27	2:06	1:50

MALSR | 1000' | 5000' via RT | TTT 113.1 R-275 | SLOTT

STRAIGHT-IN LANDING RWY 13R

ILS DA(H) 791' (200')			LOC (GS out) MDA(H) 960' (369') With D3.4 ILWN			LOC (GS out) MDA(H) 1100' (509') Without D3.4 ILWN		
FULL	TDZ or CL out	RAIL or ALS out		RAIL out	ALS out		RAIL out	ALS out
A	RVR 18 or ½	RVR 24 or ½	RVR 40 or ¾	RVR 24 or ½	RVR 40 or ¾	RVR 50 or 1	RVR 24 or ½	RVR 40 or ¾	RVR 50 or 1
B								
C				RVR 40 or ¾	RVR 60 or 1¼		RVR 50 or 1	1½
D								

CHANGES: MSA altitude.

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KDFW
DALLAS-FT WORTH INTL
JEPPESEN DALLAS-FT WORTH, TEXAS
12 APR 02 (61-10)
ILS Rwy 18R

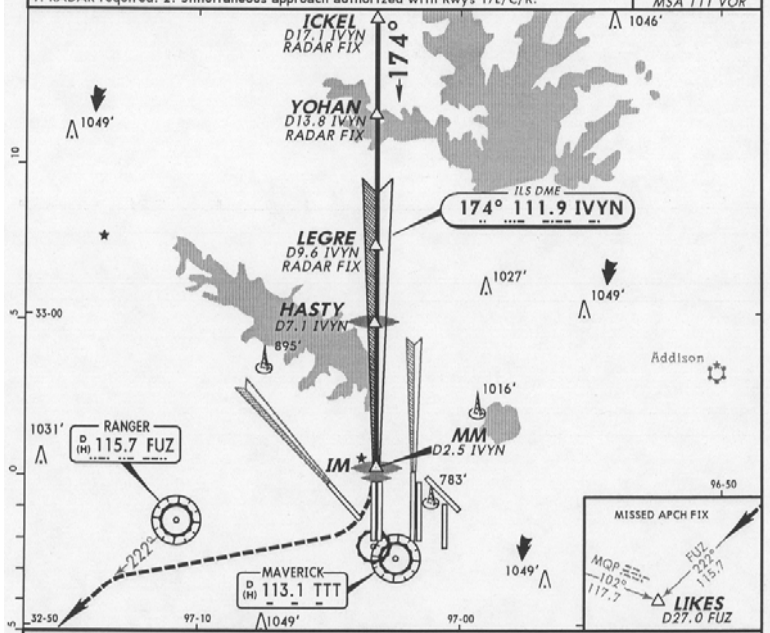
D-ATIS Arrival	REGIONAL Approach (R)	DFW Tower West	DFW Tower East	Ground West	Ground East
123.77	118.42	124.15 134.9	126.55 127.5	121.85	121.65 121.8

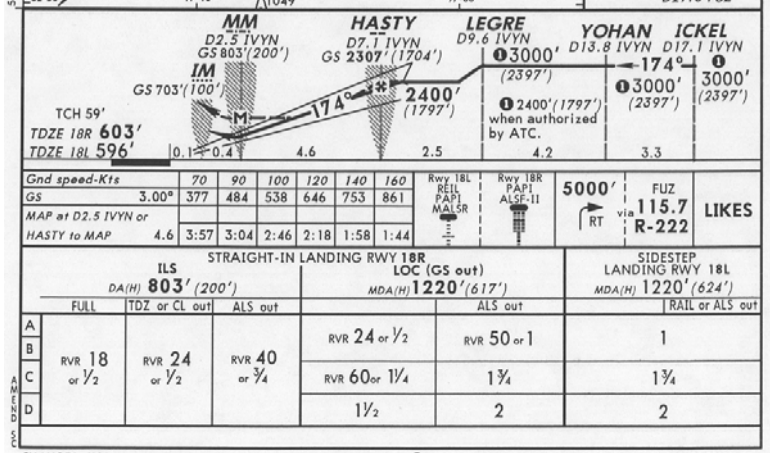
LOC IVYN	Final Apch Crs	GS HASTY	ILS DA(H)	Apt Elev 603'
111.9	174°	2307' (1704')	803' (200')	TDZE 18R 603'

MISSED APCH: Climbing RIGHT turn to 5000' outbound via FUZ VOR R-222 to LIKES INT/D27.0 FUZ.

1. RADAR required. 2. Simultaneous approach authorized with Rwys 17L/C/R.

2700' 3500' MSA TTT VOR





Gnd speed-Kts	70	90	100	120	140	160
GS 3.00°	377	484	538	646	753	861
MAP at D2.5 IVYN or HASTY to MAP 4.6	3:57	3:04	2:46	2:18	1:58	1:44

Rwy 18L REIL PAPI MALSR | Rwy 18R PAPI ALSF-II | 5000' via RT | FUZ 115.7 R-222 | LIKES

STRAIGHT-IN LANDING RWY 18R

ILS DA(H) 803' (200')			LOC (GS out) MDA(H) 1220' (617')		SIDESTEP LANDING RWY 18L MDA(H) 1220' (624')
FULL	TDZ or CL out	ALS out		ALS out	RAIL or ALS out
A	RVR 18 or ½	RVR 24 or ½	RVR 40 or ¾	RVR 24 or ½	RVR 50 or 1	1
B						
C				RVR 60 or 1¼	1¾	1¾
D				1½	2	2

CHANGES: MSA.

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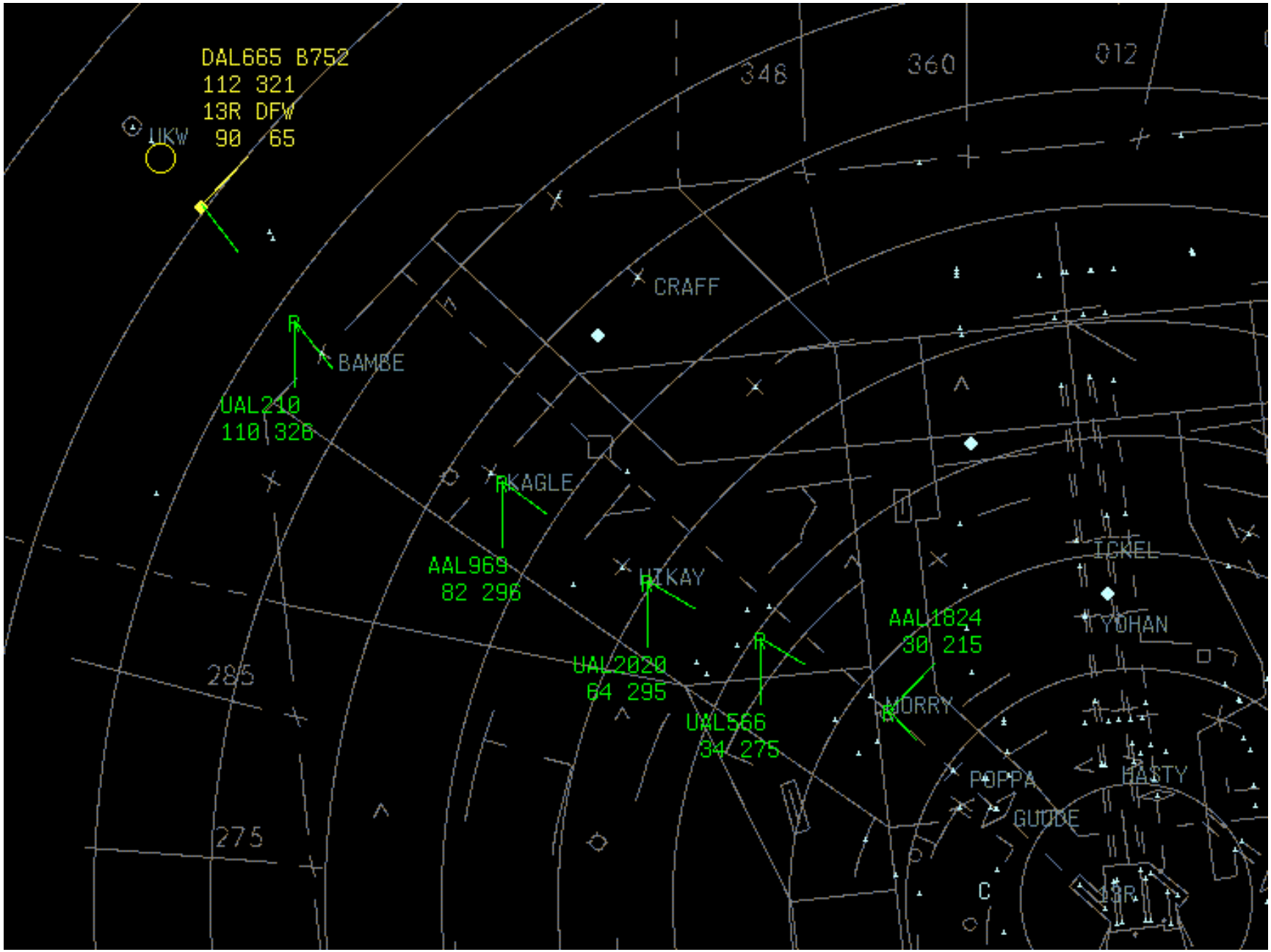
Controller Display: Self-Spacing



TRACON Datablock

Normal datablock

```
AAL1231
01  282
```

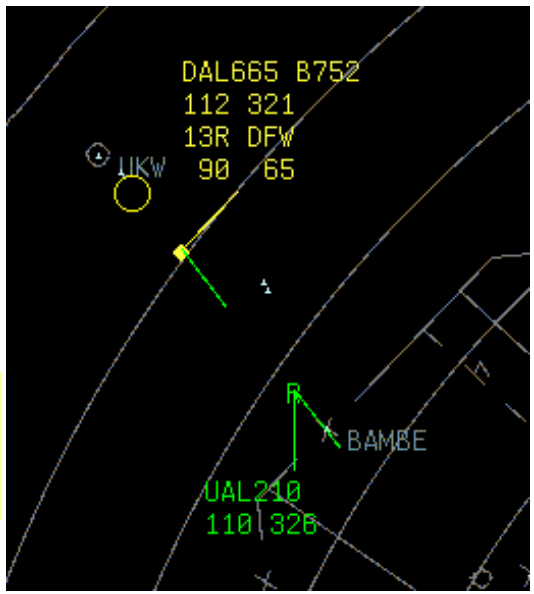
<callsign>
<alt> <gs> alternates with <runway> <type>

Expanded datablock

```
AAL123
101  282
90    82
```

<callsign>
<alt> <gs> // <runway> <type>
<advised spacing> <current spacing>

Update this screen snap with current datablock



The cursor is dwelling on the datablock of DAL665.

The orange circle shows where UAL210 was 90 seconds ago.